8. ENVIRONMENTAL IMPACT ASSESSMENT

8.1 Impact on Shallow Wells and Springs

The following items were surveyed by area:

- Number of shallow wells and springs in the vicinity of the proposed boreholes
- Water right and utilization of shallow wells and springs
- Hydrogeological conditions such as aquifer characteristics, water level and water quality of shallow wells and springs

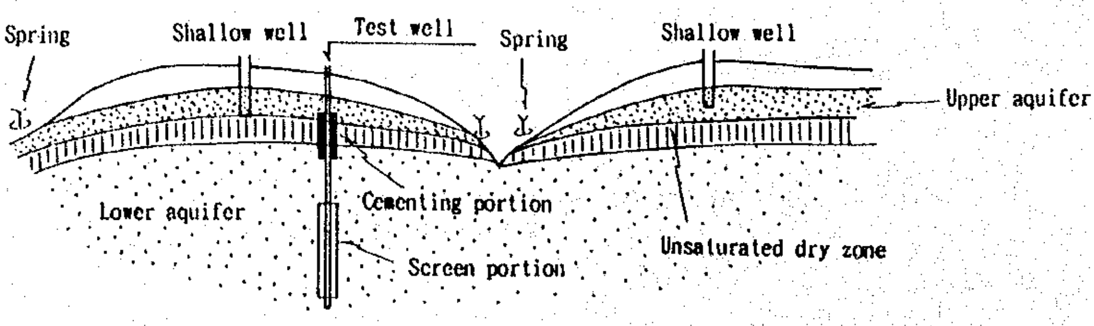
The results are summarized in Table 8.3.2. As shown in this table, there are many shallow wells and springs used for domestic and agricultural purposes. However, the construction of deep wells will not affect these shallow wells and springs due to the following hydrogeological conditions:

(a) The water of the existing shallow wells and springs in the areas are from the shallow (upper) aquifer which consists of alluvial deposits (Qa) and pumice sediments (Qp), and located at the weathered upper layer of Tertiary volcanic rocks.

(b) The screen of the deep wells are installed in lower aquifers which belong to the formation of Tertiary volcanic rocks (Qv). These lower aquifers are unconfined or semi-confined aquifers.

(c) An unsaturated dry zone separates the upper and lower aquifers.

(d) Groundwater will leak from the upper aquifer to the lower aquifer through the unsaturated dry zone, but artificial leakage can be mostly prevented by cementing, as illustrated below.



8.2 Impact on Domestic Sewage

The residents of the 10 municipalities were interviewed on the function and condition of existing sewers for domestic waste so as to evaluate the impacts on the quality and quantity of domestic sewage.

(1) Present situation of sewer system

Quite a high percentage of households in nine out of ten municipalities have sewer systems (50 - 100%), except in San Francisco La Unión.

These sewer systems are grouped into three types: Type-1: the sewer system for human and domestic wastewater, Type-2: the combined system for rainwater and domestic wastewater, and Type-3: the system separating human/domestic wastewater and rainwater. Type-3 is found only in San Pedro Sacatepéquez (Table 8.3.3).

The exact number of households with flush toilets is not clear, nor is known whether supplied water or stored water (hauled water) is used for flushing. However, since it is common in Guatemala to have the shower and toilet together in the same room, it is probably safe to assume that the number of households with showers would be the same as those with flush toilets. Génova, however, is an exception, as 25% of the households are installed only with flush toilets. These flush toilets are connected to the sewers.

Except in San Juan Comalapa and Sololá, these sewer systems have no sewage treatment systems, implying direct discharge of collected sewage into streams, rivers and lakes, thereby polluting surface water.

(2) Sewage quality and quantity

Information on sewage quality was obtained by interview to estimate the components of sewage, which is generally understood to be made up of wastewater from toilets, kitchens, bathrooms and private and public washing places (% of households and population in the municipal urban area).

A large percentage of sewage is composed of waste water from kitchens and private and public washing places (56 - 100%). Wastewater drained through sewer systems of several municipalities usually contain rainwater.

San Francisco La Unión has no sewer system. Therefore, waste from kitchens, washing places and showers are either naturally drained into rivers or infiltrate the ground. Human excreta is excluded here, however, because the residents in this municipality still use pit latrines.

The amount of sewage can be generally estimated as nearly equal to the amount of water domestically used. The municipality, however, has no records on the amount of water domestically used due to the absence of water meters and the fact that residents pay water fees according to the number of faucets installed in the house.

Supply amount, and the sewage drained through the sewer system is estimated within a range of 50 to 100 percent varying mainly by the type of toilet. In municipalities without drainage systems, the percentage is regarded as zero. The present sewage amount and increased sewage amount is tabulated in Table 8.3.6 and 8.3.7. Sewage amount after increased water supply amount is estimated using the same factors used in the estimation of the present sewage amount. In the present sewage amount estimation, the population, percentage of households connected to the sewer system and other factors were determined based on the interview results.

The same estimation was tried for 2010, assuming that the population growth rate will be as estimated and all municipalities are equipped with sewer systems.

In the urban areas of the ten municipalities, most of the rivers and streams are heavily polluted with sewage discharged from sewer systems without any treatment.

The amount of sewage discharged through the sewer systems will increase in accordance with the increase in water supply amount, even if the percentage of households equipped with faucets is as the present. The estimation is 1.1 (San Martín Jilotepeque) to 4.6 (Santa María de Jesús) times larger than the present amount after water supply amount is increased.

Estimations for 2010 showed that the sewage amount will be 1.5 (San Martín Jilotepeque) to 12.3 (Santa María de Jesús) times larger than at the present.

Conclusively, sewage will be the most influential pollutant in the future. The pollution load, however, is observed to be improportionate to how progressive the polluted condition is in the area.

Pollution load is obtained by multiplying the sewage amount by the pollutant concentration. Hence, an increase in water supply amount will not significantly affect pollution load.

Increase in population, however, may affect pollution load to a considerable extent.

8.3 Influence of the Construction Noise, Land Vibration, etc.

The effects of drilling noise and mud flow on populated areas were determined by interviewing residents living in the neighborhood of drilling sites in San José Pinula, San

Martín Jilotepeque, San Francisco La Unión and Génova. The test drilling sites were located near the population center of these municipalities.

None of the residents complained about the drilling activities, including drilling works carried out at night using a diesel engine generator. There were no complaints on mud either, because the drilling mud was mostly circulated in a closed system between the mud pit and the borehole, and any excess was properly drained.

The residents only complained about the wasteful use of water during well development works and pumping test.

It is concluded, therefore, that the groundwater development project will not in any way adversely affect the living environment, as drilling works are presumed to have no serious impacts.

Land subsidence, which usually results from over pumping, will not occur because the wells will be drilled mostly in geological areas of volcanic formations without thick clay beds. Land subsidence is only possible if groundwater development is carried out in areas widely and thickly distributed with alluvial deposits, especially of clayey materials.

9. WATER SUPPLY PROJECT FOR THE 10 MUNICIPALITIES

9.1 Project Formulation

9.1.1 Groundwater as Supplemental Supply Source

Based on the study on groundwater development potential in the areas in and around the 10 municipalities discussed in Chapter 7, and the water demand projection discussed in Chapter 4, a plan to develop groundwater as a supplementary supply source was established as one part of the Study.

The development plan in terms of development amount was made under the following basic concepts.

a. Target year is the year 2010.

b. The amount to be developed at each municipality is basically the difference between the water demand in 2010 and the amount supplied as of 1994, as tabulated in Table 9.1.1, with the exception of the following items c, d and e.

c. The existing supply sources with deteriorating raw water quality due to accelerated contamination will be replaced with groundwater. Therefore, the amount from existing surface water sources will not be taken into account (San Martín Jilotepeque).

d. New wells will be constructed to replace existing production wells that are almost worn out. Therefore, production amount from the existing wells will not be taken into account (San Francisco la Unión).

e. Increased intake from springs, in addition to groundwater development, was taken into consideration in places not fully utilizing spring source capacity due to pump energy conservation (San Juan Comalapa). This consideration is also based on the fact that the development of a greater amount of groundwater is not cost effective.

Groundwater development in the 10 municipalities will be carried out with due consideration to their respective estimated potential to ensure a long-term safe pumping.

9.1.2 Supply Facility Construction Plan

The scope of the water supply facility construction work in the 10 municipalities was initially limited to the following points.

a. Construction of borehole wells and installation of pumps

b. Construction of a conveyance system connecting constructed wells to existing distribution tanks

A detailed survey on existing facilities condition, however, has revealed that the above mentioned scope will not suffice for the improvement of the water supply service level in some municipalities, regardless of the development of a new water source, due mainly to the limited capacity of the distribution tank. Distribution tanks of greater capacity will have to be constructed, therefore, to increase the unit supply amount effectively.

Reservoirs will be constructed beside the existing tanks of 8 municipalities to ensure an 8 hour-supply capacity (the existing tanks in the remaining 2 municipalities are capacious).

The initial number of wells planned for construction was markedly reduced because the test wells were more productive than expected. The effective use of the test wells will satisfy the demand of 7 municipalities in 2010.

A well must be constructed in each of the municipalities of San Juan Comalapa, Sololá and Momostenango, in addition to the utilization of the test well. Another well is required for San Francisco la Unión, where the test well failed in terms of production.

The planned facilities in the 10 municipalities are tabulated in Table 9.1.2.

9.1.3 Facility Construction Cost

The total construction cost for the planned facilities in the 10 municipalities was estimated at about 4 million US$. With the inclusion of administrative/engineering expenses and a price contingency of about 10%, the project cost was estimated at about 4.8 million US$.

The project cost for each of the facilities is shown below.

Total Project Cost (Unit = US$)

Item	Foreign Cost	Local Cost	Total
Construction Cost	2,564,005	1,430,333	3,994,338
Administration and Engineering Cost	230,760	128,729	359,489
Sub-Total	2,794,765	1,559,062	4,353,827
Price contingencies	153,840	286,066	439,906
Total	2,948,605	1,845,128	4,793,733

Project Cost of the 10 Municipalities (Unit = US$)

Municipality	Foreign Cost	Local cost	Total
San José Pinula	167,335	150,513	317,848
San Pedro Sacatepéquez	153,398	30,375	183,773
Santa María de Jesús	176,775	243,100	419,875
San Martin Jilotepeque	166,145	32,137	198,282
San Juan Comalapa	1,014,225	365,844	1,380,069
Sololá	465,109	544,262	1,009,371
Santa Lucía Utatlán	167,380	109,773	277,153
Momostenango	301,311	168,276	469,587
San Francisco la Unión	127,205	104,850	232,055
Génova	209,723	95,997	305,720
Total	2,948,606	1,845,127	4,793,733

The conditions used for cost estimation are as follows:

a. Cost estimation was carried out with December 1994 price data.

b. Fixed exchange rate for US dollar to local currency (Quetzal):

US$1.00 = Q5.75

c. The cost of the following is to be estimated in US dollar and local currency:

Foreign currency portion

- Submersible motor pumps, other pumps and accessories
- Control panels
- Casings and screens
- Ductile cast iron pipes and specials
- Engineering cost for foreign consultants (foreign consultancy services)

Local currency portion

- Drilling work for the wells
- Labour cost
- Cement, sand, gravel
- Reinforcement bars
- Fuel, oil, etc.
- Engineering cost (local consultancy services)

d. Price contingency was estimated at 8% of foreign currency portion and 20% of the local currency portion in consideration of conversion rate fluctuation.

Table 9.1.1 Water Production in 1994 and Production Shortage in 2010

No.	Municipality	Population in 2010	Planned daily Supply Per Capita (1/c/d)	Water Demand in 2010 (m3/day)	Water Production in 1994				Max. Cap. of Existing Sources in 2010				Production Shortage in 2010 (m3/day)	Capacity of New Well (m3/day)	Number of Required Well *
					Natural Flow Spring	Pumped up Spring Water	Wells	Total (m3/day)	Natural Flow Spring	8-hour Pumping from Spring	24-hour Pumping from Wells	Total (m3/day)			
Gu 2	San Jose Pinula	19,970	155	3,095	-	-	821	821	-	-	818	818	-2,277	2,920	1 (0)
Gu 8	San Pedro Sacatepequez	10,140	155	1,572	-	122	98	220	-	-	294	294	-1,278	1,745	1 (0)
Sa11	Santa Maria de Jesus	14,890	155	2,308	-	-	173	173	-	-	691	691	-1,617	3,041	1 (0)
Ch 3	San Martin Jilotepeque	11,968	155	1,855	605	-	259	864	-	-	518	518	-1,337	2,186	1 (0)
Ch 4	San Juan Comalapa	19,408	155	3,008	371	27	112	510	371	144	539	1,054	-1,954	985	2 (1)
So 1	Solola	30,960	155	4,799	2,627	-	-	2,627	2,627	-	-	2,627	-2,172	1,909	2 (1)
So 4	Santa Lucia Utatlan	4,773	106	506	162	-	-	162	162	-	-	162	-344	821	1 (0)
To 5	Momostenango	16,740	155	2,595	346	294	-	640	346	294	-	640	-1,955	1,089	2 (1)
Qu18	San Francisco la Union	2,561	106	271	-	4	-	4	-	-	-	0	-271	821	1 (1)
Qu21	Genova	7,267	106	770	267	-	-	267	-	-	-	0	-770	1,365	1 (0)

* ( ) shows actual required number of well

Table 9.1.2 Project Facilities

No.	Municipality	Well			Transmission Pipe					Specified	Distribution pipe				Required
		Pumping Rate		Pumping Level	Elevation Difference	Pipe Diameter	* Distance	Head Loss	Flow Velocity	Pump Head (A)+(B)+(C)	Pipe Diameter	Distance	Head Loss	Flow Velocity	Additional Tank Vol.
		l/s	GPM	m	m	mm	m	m	m/s	m	mm	m	m	m/s	m3
Gu 2	San Jose Pinula	26.4	420	25	80	150	1,200	31.13	1.490	136.13	-	-	-	-	300
Gu 8	San Pedro Sacatepequez	14.8	230	60	40	150	1,200	10.66	0.840	110.66	-	-	-	-	-
Sa11	Santa Maria de Jesus	18.7	300	175	120	150	1,000	13.70	1.060	308.70	-	-	-	-	540
Ch 3	San Martin Jilotepeque	15.5	250	95	50	150	1,300	12.58	0.880	157.58	-	-	-	-	-
Ch 4	San Juan Comalapa No.1	11.3	180	105	60	150	1,100	5.93	0.640	170.93	150	3,315	-	-	-
	San Juan Comalapa No.2	11.3	180	105	80	150	1,200	6.47	0.640	191.47	100	4,455	-	-	270
So 1	Solola No.1	12.6	200	100	0	150	30	0.20	0.710	100.20	150	2,500	59.50	1.430	1,040
	Solola No.2	12.6	200	100	-20	150	1,100	7.25	0.710	87.25	-	-	-	-	-
So 4	Santa Lucia Utatlan	4.0	60	140	80	100	900	5.11	0.510	225.11	100	1,000	20.49	1.020	169
To 5	Momostenango No.1	11.3	180	140	80	150	800	4.31	0.640	224.31	-	-	-	-	-
	Momostenango No.2	11.3	180	140	80	150	1,200	6.47	0.640	226.47	-	-	-	-	180
Qu18	San Francisco la Union	3.1	50	180	100	100	1,000	3.54	0.390	283.54	-	-	-	-	90
Qu21	Genova	8.9	140	120	50	150	1,000	3.46	0.500	173.46	100	800	19.97	2.270	130

* Distance from well to distribution tank

9.2 Operation and Maintenance of Supply Facilities

9.2.1 Operation and Maintenance Plan

The operation and maintenance of new supply facilities in each of the 10 municipalities will be managed by one skilled operator and an assistant. The operator is responsible for the daily operation of pumping facilities and the periodical inspection of all facilities, including their adjustment, repair and replacement. Aside from being the subordinate of the operator, the assistant is also responsible for accounting and water charge collection.

INFOM is responsible for the training of the persons assigned to these posts.

9.2.2 Operation and Maintenance Cost

The operation cost mainly covers the electricity cost for pump operation, chlorine and personnel expenses. Maintenance cost includes cost for repair and replacement of pumping equipment and occasionally the partial replacement of distribution pipes. Electricity cost was calculated based on a unit cost of Q0.6 per 1 KWH and in accordance with the estimated power required for each system by municipality.

The maintenance cost was set at 10 percent of the cost of the pumping equipment. The total operation and maintenance cost by municipality is presented below.

Operation and Maintenance Cost for the 10 Municipalities

(Unit = Q)

No.	Municipality	Operation Cost			Mainte. Cost	Total	
		Electr.	Chlor.	Wages		Q/Month	Q/Year
Gu 2	San José Pinula	18,643	279	2,000	1,374	22,296	267,552
Gu 8	San Pedro Sacatepéquez	9,951	141	2,000	886	12,978	155,736
Sa11	Santa María de Jesús	31,328	208	2,000	2,452	35,988	431,856
Ch 3	San Martín Jilotepeque	9,952	140	2,000	959	13,051	156,612
Ch 4	San Juan Comalapa	9,821	271	2,000	1,044	13,136	157,632
So 1	Sololá	7,137	432	2,000	1,005	10,574	126,888
So 4	Santa Lucía Utatlán	5,000	46	2,000	944	7,990	95,880
To 5	Momostenango	12,380	234	2,000	1,063	15,677	188,124
Qu18	San Francisco la Unión	5,022	24	2,000	918	7,964	95,568
Qu21	Génova	10,023	69	2,000	1,018	13,110	157,320
	Total	119,257	1,844	20,000	11,663	152,764	1,833,168

9.3 Project Evaluation

9.3.1 General

Conceptually, evaluation of a water supply project can be conducted from the financial and economic viewpoints. Financial evaluation refers to the incremental revenues and costs of the water supply operating entity (municipal government in this Project) which occur as a result of the Project implementation. On the other hand, economic evaluation considers the effects of the improved water supply on the society at large.

On the cost side, implementation of a water supply project requires the following types of costs. First, initial investment costs are needed for the construction of the necessary water supply facilities. Then, once these facilities are constructed, recurrent costs are incurred for their proper operation and maintenance. Finally, components of water supply facilities need to be replaced, depending on their useful lives, during the assumed life of the Project, thereby originating the replacement costs. Details of these costs are presented in the Main Report as Section 9.1.3 Cost for Facilities Construction and Section 9.2.2 Operation and Maintenance Cost.

Financial benefits refer to the incremental revenues that the municipal government can collect by implementing the Project. Incremental revenues depend on the level of water charges, on the willingness-to-pay and ability-to-pay of water users, on the number of water users, and on the ability of the municipal government to collect the water charges.

Economic benefits from improved water supply, as considered in this Project, are reductions in medical expenses, reduction in fire damages, and appreciation in the value of the land. Low quality drinking water may cause diarrhea and cholera, which require additional medical treatment expenses, but these are preventable expenses. Occurrence of fire turned out to be insignificant in the communities of the Project, but it is considered as a distinct risk in such town as Santa María de Jesús, where fences around houses are made of easily combustible materials such as corn stalks and bamboos. And, there is no doubt that the value of urban land goes up when the plot is serviced with drinking water supply, thereby increasing the asset value of land owners, while simultaneously augmenting the value of social infrastructure.

9.3.2 Assumptions for the Project Evaluation

1) Table 9.3.1 shows, for each community, the basic data used in the Project evaluation, including the base population (1994), the yearly population growth rate, the average family size, the average value of a house and land, the lower and upper bounds of the

willingness-to-pay for drinking water supply services, and the incidence of diarrhea.

2) For revenue estimation, the Project was assumed to supply drinking water to 100% of households in the urban areas of the target communities. In other words, water supply services currently existing in the target communities were deemed as intermittent and negligible in volume. Hence, existing water supply services were deemed as grossly inadequate to apply the water service charges indicated by the willingness-to-pay survey, which assumed satisfactory service for water users.

3) Municipal governments were assumed to collect 80% of billings for water service charges determined on the basis of the willingness-to-pay survey.

4) The number of households in a given community in a given year was assumed to be a function of its 1994 population, and the community specific population growth rate and average family size.

5) Each family was assumed to live in an independent house, and the value of a dwelling was assumed to be divided equally between the house and the land.

6) Fire prevention benefits were assumed to amount to 0.5% of the community specific average value of a house.

7) Land appreciation benefits were assumed to amount to 2% of the community specific average value of a plot of land.

8) Diarrhea prevention benefits were estimated on the basis of the assumed 30% of the population resorting to health centers, the community specific incidence of diarrhea among the patients, and a treatment cost of Q.30 per case of diarrhea (savings for the Ministry of Public Health), assuming that the diarrhea strikes once a month during the six-month period of the rainy season.

9) The useful life of the Project was assumed to be 30 years, setting 2010 as the target year.

10) Market prices were used in the estimation of economic benefits because of the following two reasons: (a) the labor input of the Project comprised a small proportion of total costs and consisted mostly of skilled labor, whose valuation is usually assumed to reflect marginal productivity, and (b) price distortion of traded goods was slight, as indicated by the Standard Conversion Factor (SCF=0.97) which was calculated as follows.

SCF=(Import+Export)/(Import+Import Tax)+(Export-Export Tax)

Standard Conversion Factor of Guatemala

Unit: US$1,000

Year	Export	Export Tax	Import	Import Tax
1989	2,159,079	9,873	4,195,202	74,964
1990	1,162,970	836	1,648,799	97,455
1991	1,202,194	327	1,851,254	123,782
1992	1,295,291	109	2,462,757	213,764
Total	5,819,534	11,145	10,158,012	509,964

SCF = 0.969725227
SCF = Standard Conversion Factor

Source: 1) Banco de Guatemala, Boletín Estadístico, Enero-Febrero-Marzo 1994
2) Instituto Nacional de Estadística, Anuario de Comercio Exterior 1992

9.3.3 Evaluation Results

(1) Financial Evaluation

Cash flows (CF) were calculated for the Project and for each municipality, on the basis of estimated revenues and costs. Cash flows calculation for the Project is presented in Table 9.3.2. Cash flows served to determine the evaluation index for this Project, that is, the financial internal rates of return (FIRR) for each municipality and for the Project, which are summarized below.

Municipality/Project	FIRR (%)
San José Pinula-high WTP	6.52
San Pedro Sacatepéquez-high WTP	9.31
Santa María de Jesús-high WTP	No solution
San Martín Jilotepeque-high WTP	7.40
San Juan Comalapa-high WTP	No solution
Sololá-low WTP	2.60
Sololá-high WTP	18.83
Santa Lucía Utatlán-high WTP	3.68
Momostenango-high WTP	27.43
San Francisco La Unión-high WTP	No solution
Génova-high WTP	No solution
The Project	6.56

Financially, the Project is feasible only if revenues are estimated with the upper bound willingness-to-pay. Further, the Project should be implemented using a very favorable soft financing scheme, since the FIRR is a modest 6.56%. The overall Project feasibility implies the need for a unifying entity. This is because, individually, only six of the selected ten municipalities showed positive levels of

FIRR. Then, the unifying body could resort to cross subsidization among municipalities so as to make the Project feasible.

Of the four municipalities where the FIRR could not be calculated, three (Santa María de Jesús, San Francisco La Unión and Génova) had negative cash flows during the whole Project life. The reasons, however, were different. Negative cash flows in San Francisco La Unión and Génova were basically due to the small number of households. On the other hand, in Santa María de Jesús, the costs were unusually high due to the hilly topography, which required wells to be located in distant lowlands, thereby incurring high investment cost and high operation cost of the water distribution system.

San Juan Comalapa had positive cash flows during some years of the Project life, despite a low WTP, but the surplus of revenues over expenditures were too small to permit calculation of the FIRR.

(2) Economic Evaluation

The economic benefits of the Project were estimated in terms of savings of the Ministry of Public Health and Social Welfare in medical treatment expenses of diarrhea, reduction in fire damages, and land value appreciation. These estimated benefits and costs are also presented as cash flows (CF), for the Project and for each municipality. Table 9.3.3 presents CF for the Project. The relevant evaluation indices, namely,the economic internal rates of return (EIRR) are summarized below.

Municipality/Project	EIRR (%)
San José Pinula	96.75
San Pedro Sacatepéquez	100.01
Santa María de Jesús	42.01
San Martín Jilotepeque	89.04
San Juan Comalapa	13.19
Sololá	26.28
Santa Lucía Utatlán	No solution
Momostenango	24.36
San Francisco La Unión	No solution
Génova	8.01
The Project	30.45

The value of the EIRR at 30.45% indicates a significant positive impact of the Project on the society. Still, EIRR could not be calculated in Santa Lucía Utatlán, despite the cash flow being positive during some years of the Project life, and in San Francisco La Unión, where the cash flow was negative during the whole Project life. The insufficient or negative cash flows in these two municipalities were due to a combination of small number of households and low value of dwellings.

The largest impact came from land appreciation benefits. This indicates that the impacts would be larger in municipalities where the land value is already high, which are due either to the proximity to Guatemala City (San José Pinula, San Pedro Sacatepéquez) or to a favorable location on a main road (Sololá).

9.3.4 Sensitivity Analysis

(1) Financial Rates of Return

Sensitivity analysis was conducted under two scenarios, one with a 10% reduction in revenues, and the other with a 10% increase in costs. Results of sensitivity analysis are summarized below.

Municipality/Project	FIRR (%)		
	Base Case	Revenues (-10%)	Costs (+10%)
San José Pinula	6.52	3.97	
San Pedro Sacatepéquez	9.31	6.45	
Santa María de Jesús	No sol.	No sol.	
San Martin Jilotepeque	7.40	4.61	4.88
San Juan Comalapa	No sol.	No sol.	No sol.
Sololá	18.83	16.90	17.08
Santa Lucía Utatlán	3.68	2.08	2.23
Momostenango	27.43	24.22	24.51
San Francisco la Unión	No sol.	No sol.	No sol.
Génova	No sol.	No sol.	No sol.
The Project	6.56	4.80	4.97

The above table shows that the Project is slightly more sensitive to a 10% reduction in revenues than to a 10% increase in costs. This remark is also valid for all municipalities.

The FIRR of the Project decreased by around 25% in response to either a 10% decrease in revenues or a 10% increase in costs. Municipalities more sensitive than the Project were San José Pinula, San Pedro Sacatepéquez, San Martín Jilotepeque and Santa Lucía Utatlán. On the other hand, Sololá and Momostenango were quite insensitive, showing only around a 10% reduction in the values of FIRR in response to either a 10% decrease in revenues or a 10% increase in costs.

It is understood that collection of water charges is a truly difficult task facing the water supply operating entity. Therefore, an additional sensitivity analysis was conducted by assuming a 70% collection rate, instead of the initially assumed 80% of billings. As a result, the Project

FIRR declined from 6.56% to 4.34%, that is, a 10% reduction in collection rate caused a 35% decline in the FIRR of the Project. Taking the municipalities individually, only Sololá and Momostenango were less sensitive to reduced collection rates than the Project as a whole. Details are shown below.

Municipality/Project	Base Case FIRR (%)	
	Bill Collection Rates	
	80%	70%
San José Pinula	6.52	3.26
San Pedro Sacatepéquez	9.31	5.68
Santa María de Jesús	No sol.	No sol.
San Martín Jilotepeque	7.40	3.85
San Juan Comalapa	No sol.	No sol.
Sololá	18.83	16.41
Santa Lucía Utatlán	3.68	1.65
Momostenango	27.43	23.41
San Francisco la Unión	No sol.	No sol.
Génova	No sol.	No sol.
The Project	6.56	4.34

(2) Economic Rates of Return

Sensitivity analysis was conducted under two scenarios, one with a 10% reduction in economic benefits, and the other with a 10% increase in costs. Results of sensitivity analysis are summarized below.

Municipality/Project	EIRR (%)		
	Base Case	Benefits	Costs
		(-10%)	(+10%)
San josé Pinula	96.75	86.03	87.00
San Pedro Sacatepéquez	100.01	89.33	90.37
Santa María de Jesús	42.01	36.22	36.75
San Martín Jilotepeque	89.04	78.91	79.83
San Juan Comalapa	13.19	11.55	11.70
Sololá	26.28	23.73	23.97
Santa Lucía Utatlán	No sol.	No sol.	No sol.
Momostenango	24.36	21.42	21.69
San Francisco la Unión	No sol.	No sol.	No sol.
Génova	8.01	6.06	6.25
The Project	30.45	26.98	27.29

The above table shows that the Project is slightly more sensitive to a 10% reduction in benefits than to a 10% increase in costs. This remark is also valid for all municipalities.

The EIRR of the Project decreased by around 10% in response to either a 10% reduction in benefits or a 10% increase in costs. Only Génova was significantly more sensitive than the Project with about 25% decrease in EIRR in response to a 10% reduction in benefits or a 10% increase in costs. Municipalities slightly more sensitive than the Project were Santa María de Jesús, San Juan Comalapa and Momostenango.

The largest impact of the Project on the society came from land value appreciation benefits. Therefore, an additional sensitivity analysis was conducted by assuming different rates of land appreciation benefits depending on muncipalities. Specifically, instead of the initially assumed 2% of the value of the land for all muncipalities, a 5% value appreciation was assumed for San José Pinula and San Pedro Sacatepéquez (municipalities near Guatemala City), and 3% for Sololá (located on a main road). As a result, the EIRR of the Project increased from 30.45% to 44.92%.

9.3.5 Overall Evaluation and Suggestions

(1) General

The people in the Study Area face a critical shortage of drinking water supply, which is presumed to continue into the foreseeable future. Due to the lack of appropriate surface water sources, the goal of the Project is to satisfy the water demand up to the year 2010 through the development of new groundwater sources. The beneficiary population in the target year is estimated at around 139,000 persons or 23,500 households.

The choice of groundwater as new water sources is reasonable, since test drillings showed that the Study Area is endowed with groundwater of good quality, requiring only chlorination prior to distribution. The development of these new water sources will permit regular distribution of good quality drinking water, instead of the extremely irregular water supply service prevailing at present.

The FIRR of the Project may not be fully convincing at 6.56%, but the benefits of the Project on the society far outweigh this concern as indicated by the 30.45% EIRR. There is no question that the ten communities included in the Project are in dire need for improved supply of drinking water. Therefore, the Project should be urgently implemented, especially if soft loans or grants can be obtained for financing the initial investments.

However, a great deal of caution is required in the Project implementation. This is because revenues in some municipalities are insufficient to cover even the operation and maintenance costs. Suggestions on ways to overcome this situation are presented below.

(a) Executing Unit of the Project within INFOM

As already mentioned elsewhere, if an administrative unit is set up within INFOM for the Project execution, it will become the unifying entity of the ten municipalities. Then, it will be possible to implement a cross subsidy scheme among the ten municipalities, whereby financially weaker municipalities would be subsidized by financially stronger municipalities within the Project.

In reality, implementation of the cross subsidy scheme would be quite difficult. In addition to administrative difficulties, there is a question of fairness, since none of the ten municipalities is sufficiently well-off as to subsidize other communities.

(b) Firm Commitment to Use Other Revenues

Alternative local revenue sources of municipalities are virtually non-existent. An analysis of municipal budgets showed that both current income and capital income depend heavily on subsidies or transfers from the Central Government. Current income subsidies come as transfers from the Finance Ministry (15% to 40% of current income), while the capital income subsidies (95% to 99% of capital income) come as transfers from the Central Government, based on a Constitutional provision to return 8% (10% since 1995) of current income of the Central Government to municipalities through INFOM. Altogether, the subsidies for current income and for capital income amounted to between 60% and 93% of the total municipal budget.

Whether or not to use these subsidies for drinking water supply is a decision to be made by each municipality. Yet, using these subsidies to finance water suplly costs may be the only option available in the immediate future. Hence, it would be acceptable in the short-run, but over the long-run, water users in each municipality should be able to finance at least the operation and maintenance costs of their own drinking water supply service.

(c) Self-sustaining Water Supply Service

As illustrated in the above description, the ten municipalities are financially weak in terms of independent local revenue sources. This situation is exacerbated by the general perception existing in Guatemala that drinking water should be supplied free of charge. This perception of drinking water as a basic necessity exists, to some extent, in most countries, but it is particularly strong in Guatemala. To make matters worse, drinking water supply is a service provided by municipalities, where mayors are elected by popular vote, thereby making it politically difficult to make the financially correct decision of increasing water charges in step with rising costs.

This perception needs to be changed. The general public must be made perfectly aware of the costs involved in securing water sources and supplying safe drinking water through appropriate distribution facilities. Paying for all these costs through the properly set water charges will ultimately benefit the consumers themselves, since cost recovery will make continued improvements possible in water supply facilities. Conversely, low water charges that do not cover the costs will only accomplish the perpetuation of less-than-satisfactory water supply service.

Consequently, revenue shortfalls can be covered by government subsidies in the short-run, but water charges in the long-run should ideally cover all costs. To get water users to pay the appropriate water charges, a well organized and long-term public education campaign is necessary. This education campaign should encompass children and adults, formal and informal education systems, and should resort to systematic use of the mass media.

At the same time, the ten municipalities should do their utmost to improve management and operation of their drinking water supply services. One aspect of great potential impact refers to the installation of water meters for the measurement of actual water consumption by each user. The installation of water meters should be combined with the adoption of a water service rate, which ideally will be structured as increasing blocks, that is, as water consumption increases, so does the unit water service charge.

If an increasing block rate structure is difficult to be implemented, a simpler water rate structure should be adopted on the basis of a basic charge in combination with excess consumption charge. The basic charge should be low and, accordingly, entitle water consumers to use a relatively low volume of water per month. Still, this low volume may be enough for a great deal of households.

Either water rate structure will allow a better correlation between consumption of and payment for water. In other words, fairness will be achieved, as high volume consumers will have to pay more, and viceversa. This will be quite a contrasting change from the current practice of unmetered consumption, whereby a "title" holder has the right to consume so much water per month (e.g. 30,000 liters per month), without much regard for actual consumption. Fairness is expected to induce good will among consumers, who may be more willing to pay for water services. Then, municipal finance will improve with respect to water supply service, thereby contributing to the probability of success of the Project.

An additional benefit of the increasing block rate structure is the conservation effect, as unit price of water will be higher as the consumption increases. This will necessarily compel water consumers to use water more rationally than under the presently prevailing unmetered consumption.

(2) Required Water Charges

To be fair, residents of each community should pay the costs associated with the drinking water supply service in their own community. These costs are divided into Operation and Maintenance Costs on one side, and Investment and Replacement Costs on the other. These costs are specific to each community, as water supply facilities were designed according to the characteristics of each community. Further, the monthly water service charges for each family is inversely proportional to the population size or the number of households in the community. Hence, a community with a small population is in disadvantage, as the monthly water service charges to be borne by each household are relatively high.

Operation and Maintenace Costs are incurred daily, and are easily estimated on a monthly or yearly basis. On the other hand, Investment Costs are incurred initially, followed by periodic Replacement Costs of diverse components at the end of their useful lives, thereby requiring conversion into yearly or monthly costs. Then, the monthly charges to cover Investment Costs could be properly allocated among the community residents.

Therefore, in order to estimate the monthly charges for investment costs, Annual Equivalent Costs were initially calculated by applying the Capital Recovery Factor at 10% interest rate to the estimated investment costs. The Capital Recovery Factor is given by the following formula.

$$CRF = [i(1+i)^n] / [(1+i)^n - 1]$$

where,

CRF: Capital Recovery Factor
i: interest rate
n: number of year

The resulting monthly water service charges per household by municipality are shown below.

Municipality	Required Water Charges (Q/fam./mo.)		
	O & M	Investmet	Total
San Jose Pinula	15 (0%)	11	26(+73%)
San Pedro Sacatepéquez	13 (-24%)	9	22(+29%)
Santa María de Jesús	23 (+130%)	13	36(+260%)
San Martín Jilotepeque	8 (-20%)	6	14(+40%)
San Juan Comalapa	7 (+40%)	32	39(+680%)
Sololá	7 (-83%)	31	38(-5%)
Santa Lucía Utatlán	29 (-3%)	49	78(+160%)
Momostenango	11 (-73%)	16	27(-33%)
San Francisco La Unión	39 (+56%)	56	95(+280%)
Génova	24 (+380%)	27	51(+920%)

Note: The percentage in parentheses (%) indicates the change over the upper bound willingness-to-pay.

When the total water charges indicated above were applied, the resulting financial rate of return of the Project was 16.71%. The FIRR values by municipality are shown below.

Municipality/Project	FIRR (%)
San Jose Pinula	21.17
San Pedro Sacatepéquez	16.79
Santa María de Jesús	16.22
San Martín Jilotepeque	16.79
San Juan Comalapa	12.96
Sololá	17.87
Santa Lucía Utatlán	20.49
Momostenango	16.80
San Francisco La Unión	15.47
Génova	20.46
The Project	16.71

Further, sensitivity analysis indicated that these FIRR values were quite insensitive either to a 10% decrease in revenues or a 10% increase in costs. As a matter of fact, only in San Pedro Sacatepéquez and Santa María de Jesús the FIRR values decreased by around 20% in response to a 10% reduction in revenues or a 10% increase in costs, while responses of the remaining municipalities fluctuated between 10% and 15%.

In summary, the required total water charges per month may be too heavy a financial burden for households in such small municipalities as Santa Lucía Utatlán, San Francisco La Unión and Génova. Municipal authorities in these small communities will almost inevitably have to use part of the subsidies from the Central Government to ease the financial burden on the community residents. However, if the Project is expected to be successfully implemented, municipal authorities in all communities should truly strive to educate their own residents, and convince water users to pay, at the very least, the operation and maintenance costs of their own drinking water supply service.

Table 9.3.1 Basic Data for the Project Evaluation
Cuadro 9.3.1 Datos Basicos para la Evaluacion del Proyecto

Community	Population Growth Rate (%)	Population in 1994 (Persons)	Population in 2010 (Persons)	Household Size (Persons)	WTP LowerBound (Q/month)	WTP Upper Bound (Q/month)	AverageValue of a House (Q)	Diarrea Incidence (%)
San Jose Pinula	3.64	11,277	19,970	6.1	10	15	60,000	31.28
San Pedro Sacatepequez	1.78	7,652	10,140	5.8	5	17	60,000	16.13
Santa Maria de Jesus	1.85	11,107	14,890	5.6	10	10	35,000	60.00
San Martin Jilotepeque	1.63	5,482	7,103	4.2	10	10	35,000	12.00
San Juan Comalapa	1.75	14,710	19,408	5.6	3	5	25,000	22.22
Solola	4.52	15,254	30,960	7.6	12	40	40,000	9.52
Santa Lucia Utatlan	5.03	2,176	4,773	6.3	10	30	15,000	10.00
Momostenango	3.03	10,390	16,740	5.7	6	40	20,000	31.59
San Francisco La Union	2.57	1,707	2,561	6.7	10	25	8,000	25.00
Genova	4.14	3,800	7,267	5.4	5	5	15,000	30.00

Table 9.3.2 The Project Incremental Revenues and Costs

Cuadro 9.3.2 Ingresos y Costos Incrementales del Proyecto

Year	Population (Persons)	Hholds. (Number)	Low WTP (1,000Q)	High WTP (1,000Q)	Inv&Repl (1,000Q)	O&M (1,000Q)	TotalCost (1,000Q)	Low CF (1,000Q)	High CF (1,000Q)
1998	97,714	16,824	0	0	26,365	0	26,365	-26,365	-26,365
1999	100,536	17,287	1,323	3,141	0	1,835	1,835	-512	1,306
2000	103,453	17,765	1,363	3,244	0	1,835	1,835	-472	1,409
2001	106,468	18,258	1,403	3,352	0	1,835	1,835	-432	1,517
2002	109,585	18,768	1,445	3,463	0	1,835	1,835	-390	1,628
2003	112,809	19,294	1,489	3,579	0	1,835	1,835	-346	1,744
2004	116,142	19,837	1,534	3,699	0	1,835	1,835	-301	1,864
2005	119,590	20,398	1,580	3,823	0	1,835	1,835	-255	1,988
2006	123,157	20,978	1,629	3,952	0	1,835	1,835	-206	2,117
2007	126,846	21,577	1,679	4,086	0	1,835	1,835	-156	2,251
2008	130,664	22,196	1,730	4,225	1,696	1,835	3,531	-1,801	694
2009	134,614	22,836	1,784	4,369	0	1,835	1,835	-51	2,534
2010-2027	138,703	23,497	1,839	4,519	0	1,835	1,835	4	2,684

FIRR = 0.0656

Table 9.3.3 Economic Benefits of the Project
Cuadro 9.3.3 Beneficios Economicos del Proyecto

Year	Population (Persons)	Houses (Number)	House&Land (1,000Q)	Fire Prev (1,000Q)	Land App (1,000Q)	Diarrea (1,000Q)	EconBenef (1,000Q)	Inv&Repl (1,000Q)	O&M (1,000Q)	TotalCost (1,000Q)	CashFlow (1,000Q)
1998	97,714	16,824	597,996	0	0	0	0	26,365	0	26,365	-26,365
1999	100,536	17,287	614,583	1,536	6,146	1,373	9,055	0	1,835	1,835	7,220
2000	103,453	17,765	631,708	1,579	6,317	1,409	9,305	0	1,835	1,835	7,470
2001	106,468	18,258	649,390	1,623	6,494	1,447	9,564	0	1,835	1,835	7,729
2002	109,585	18,768	667,650	1,669	6,676	1,485	9,831	0	1,835	1,835	7,996
2003	112,809	19,294	686,508	1,716	6,865	1,525	10,107	0	1,835	1,835	8,272
2004	116,142	19,837	705,987	1,765	7,060	1,567	10,391	0	1,835	1,835	8,556
2005	119,590	20,398	726,109	1,815	7,261	1,609	10,685	0	1,835	1,835	8,850
2006	123,157	20,978	746,899	1,867	7,469	1,653	10,989	0	1,835	1,835	9,154
2007	126,846	21,577	768,380	1,921	7,684	1,698	11,303	0	1,835	1,835	9,468
2008	130,664	22,196	790,579	1,976	7,906	1,744	11,627	1,696	1,835	3,531	8,096
2009	134,614	22,836	813,522	2,034	8,135	1,792	11,961	0	1,835	1,835	10,126
2010-2027	138,703	23,497	837,235	2,093	8,372	1,842	12,307	0	1,835	1,835	10,472

EIRR = 0.304500

10. Conclusions and Recommendations

10.1 Conclusions

The major conclusions derived from the results of the Study are as follows:

1) The Water Supply Source in the Central Plateau Area

In many of the municipalities the spring water sources should be effectively utilized, because the quantity is stable and the quality is good.

In order to upgrade the service level and meet the increasing water demand, groundwater (deep and shallow wells) and surface water (rivers and lakes) utilization should be taken into consideration in addition to springs.

The use of surface water however should not be intended for drinking due to the progressive deterioration in water quality. Use of surface water should only be planned after countermeasures against sewage and waste disposal are taken and the waters are clean enough for human use. Given this, future additional supply source development will focus on groundwater.

2) Groundwater Development Potential

Groundwater development is very difficult or almost impossible in the northern part of the Study Area, which hydrogeologically is widely underlain with basement rocks such as metamorphic rocks and cretaceous rocks. Groundwater development is possible, however, in the greater part of the Study Area where basement rocks are overlain by Tertiary and Quaternary volcanic rocks. Pumping of groundwater from the uppermost layer of Quaternary volcanics and their secondary deposits, widely distributed in the intramountain basins, has been going on since the 1960s, particularly from the basins of the Departments of Guatemala, Sacatepéquez and Quetzaltenango.

The results of the hydrogeological study, including test drilling to the Tertiary volcanic rock formation, revealed that the long-term pumping of groundwater is possible from Tertiary volcanic rocks, which are mostly more compact and massive than the rocks of the Quaternary Formation. However, well construction works may not always hit a productive aquifer. Drilling of the Tertiary volcanic formation, therefore, should be focused at cracked or fractured zone, particularly targeting the faults within the zone, as they are usually abundantly filled with water.

The groundwater level in the majority of the Central Plateau area is generally very deep due to topographic features, making the groundwater development very expensive both for well construction and pumping.

The development of groundwater, particularly from Tertiary rock formations, would therefore require sufficient budgetary allocation.

3) Present Administration of Water Supply Services

The municipal government is responsible for the formulation of water supply and facility plans, project implementation and day-to-day operation including collection of water fees, and is technically and financially assisted by INFOM. The majority of the municipal governments, however, have poor policies concerning water supply and are inexperienced in the planning and implementation of programs. Moreover, municipal officials do not recognize the water supply scheme as one of the most important public services.

The physical surroundings of the water supply sources of many of the municipalities are insanitary and are left unimproved. Water is also distributed without treatment. These factors are not only a result of the poor economic status of the area but also of municipal officials' lack of understanding of the importance of public services.

Beneficiaries usually put little importance in the improvement of their living environment and have little desire to participate in the implementation of improvement programs. They do not see the point in paying for water supply services since they have long been accustomed to free spring water. Their willingness-to-pay was surveyed to be generally low. Again, this could be attributed to lack of encouragement from municipal officials.

4) Water Source Development Strategy

Fifty-four municipalities were categorized by water source development potential and facility maintenance capacity. Strategies for water source development were established by category.

It is desirable to select the water supply source to be developed in the future based on the aforementioned categorization. However, if the present administration of water supply services is to be significantly improved, the categorization of some municipalities may have to be changed.

5) Groundwater Development Plan for the 10 Selected Municipalities

The groundwater development plan, which includes facility design and project cost estimation, for the 10 prioritized municipalities was incorporated in the Study.

The facilities to be constructed are designed based on the following:

- The quantity of groundwater to be developed is determined as the difference between the demand in 2010 and the existing source capacity, excluding sources presumed to become unproductive in the future.

- The facilities to be constructed are (1) new deep wells with pumps, (2) transmission pipes and (3) supplementary distribution tanks. Supplementary distribution tanks will be constructed in municipalities where the capacity of tanks is insufficient for an 8-hour supply. New wells will only be constructed in the 4 municipalities where the production capacity of test wells is not enough to satisfy the projected demand for 2010, and where the test wells was unsuccessful (San Francisco La Unión).

The facility design includes the replacement of 7,770m of distribution pipeline in San Juan Comalapa.

The construction of the aforementioned facilities, excluding the 9 wells, is estimated to cost a total of US$4.8 million with an average annual O & M cost of about US $320,000.

6) Project Evaluation

Assuming a project life of 30 years, the Project is assessed to be barely feasible as the financial internal rate of return (FIRR), calculated considering the best possible situation, was only 6.56%.

A very favorable financial plan should, therefore, be considered for the implementation of the project.

The economic internal rate of return (EIRR) of the project, however, was estimated at 30.45%, a figure that indicates significant positive impacts of the Project on the society.

10.2 Recommendations

1) Recommendations on Tariff Policy

Groundwater in the Central Plateau Area will be developed as the future major water supply source in order to meet the growing water demand.

The construction and operation of groundwater supply facilities however will be more costly than those for the spring source. Since the municipality will not be able to maintain these facilities with the present water fee collection system, the following tariff policies are recommended.

(1) All beneficiaries in the municipality shall be obliged to pay water charges, without regard for the supply system through house connections or public standposts.

(2) Different water charges should be applied for the use of house connections and public standposts. Households without connections shall pay the same charges as the use of public standposts.

(3) Separate "Tariff Register Books" shall be prepared for households with house connections and those using public standposts, for a highly efficient collection.

(4) Reference water rates should be established nationwide. This could facilitate the setting of water rates at the municipal level, on the basis of percent variation as a function of the population and facilities types.

(5) In the future, every house with connections shall be installed with a water meter and the water rate system will be changed from a fixed system to a variable system wherein rates are determined according to the water amount consumed.

2) Reinforcement of INFOM's Guidance Program

Since many of the municipal governments lack the ability to plan and implement programs, maintain a sanitary environment, maintain and operate water supply facilities, and lead the residents in various community activities, INFOM is recommended to carry out the following to strengthen the capability of municipal governments.

(1) To periodically hold seminars for managers and training workshops for the people involved in the operation and maintenance of water supply facilities.

(2) To invigorate the activities of the officials of INFOM's branch offices.

3) Recommendations for Project Implementation

An evaluation of the groundwater development plan for the 10 prioritized municipalities resulted in an EIRR of 30.45%, indicating significant positive impacts of the project on communities in the Study Area.

Since there is no doubt about the need for improved drinking water supply in the 10 municipalities, the implementation of the project should be carried out urgently.

However, if the Project were to be divided into 10 sub-projects, and each separately evaluated, some municipalities will no be able to cover even the operation and maintenance costs. In order to overcome this situation, use of subsidies from the Central Government is recommended to cover the water supply costs in the short-run. But over the long-run, implementation of a continued education campaign is recommended to raise residents awareness on the importance of paying appropriate water rates so as to improve the willingness-to pay of water users.